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H04B 10/18

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H4B BK18

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GB 2260048 A EP 0539177 A2 US 4238648 A

(58) Field of search
UK CL (Edition L) H4B BK18
INT CL[5] H04B

(54) Optical fibre transmission system

(57) The system comprises an optical fibre 2 between transmitter 3 and receiver 4. Amplifiers 1 are provided at regular intervals. The optical fibre has zero chromatic dispersion at a longer wavelength than that used for transmission; the consequential chromatic dispersion is annulled by dispersive elements 5 having a dispersion equal and opposite to the preceding length of optical fibre.

Fig. 1

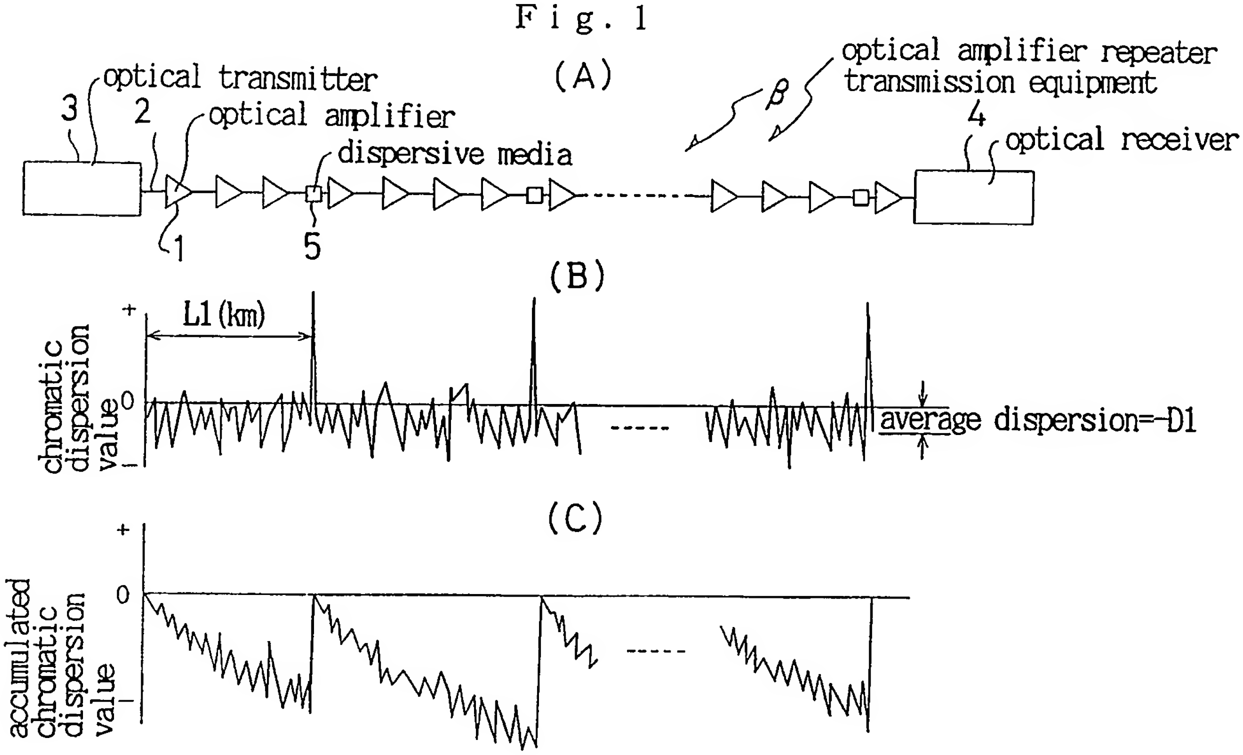

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Fig. 1

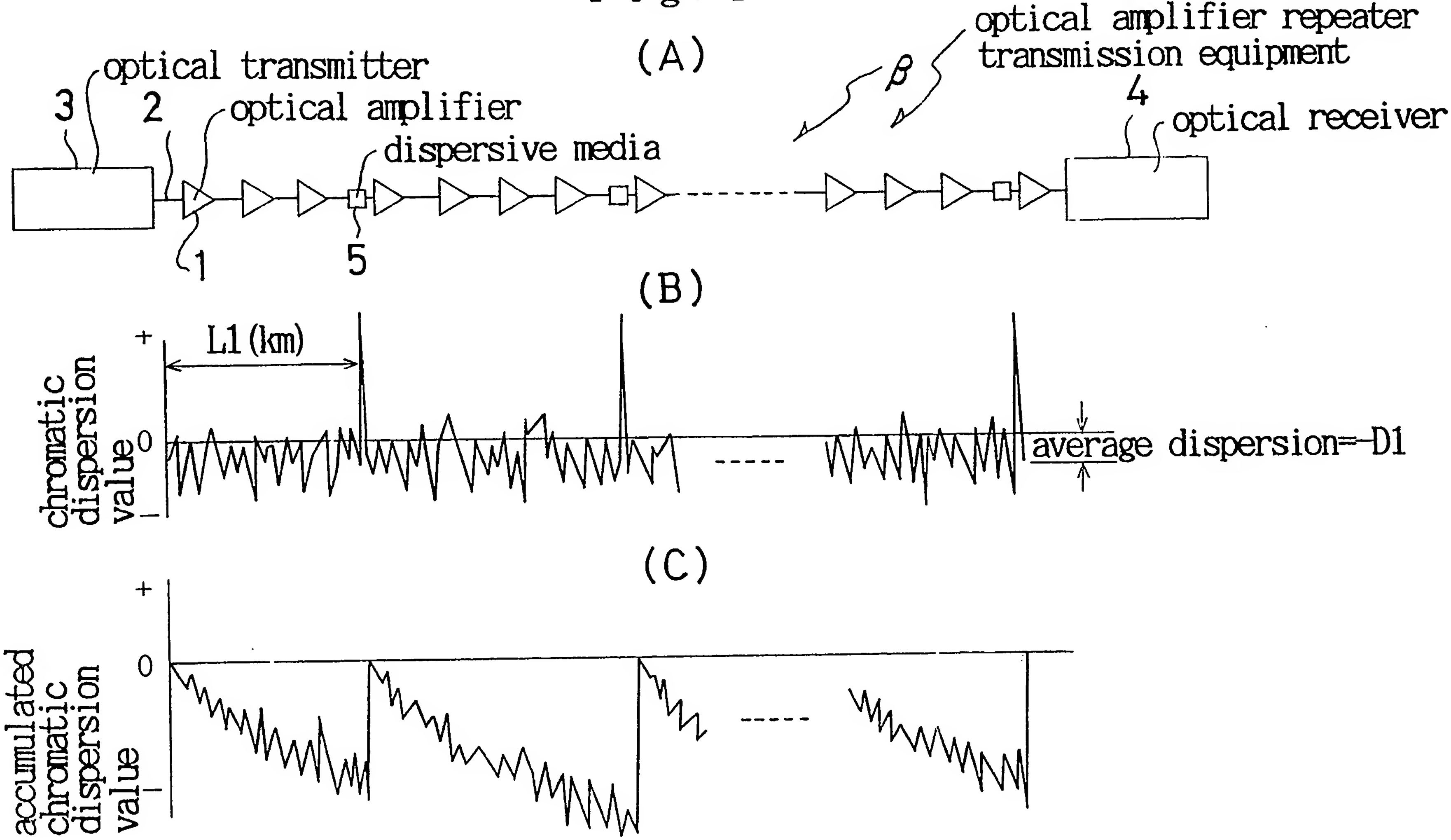
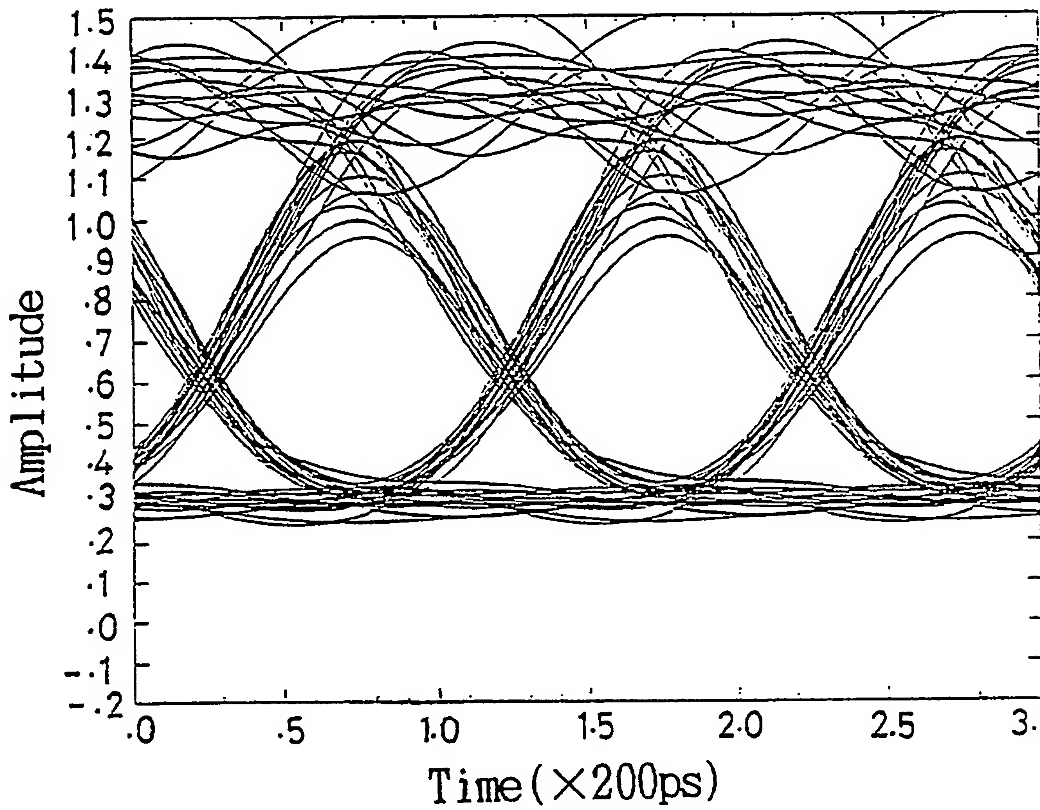
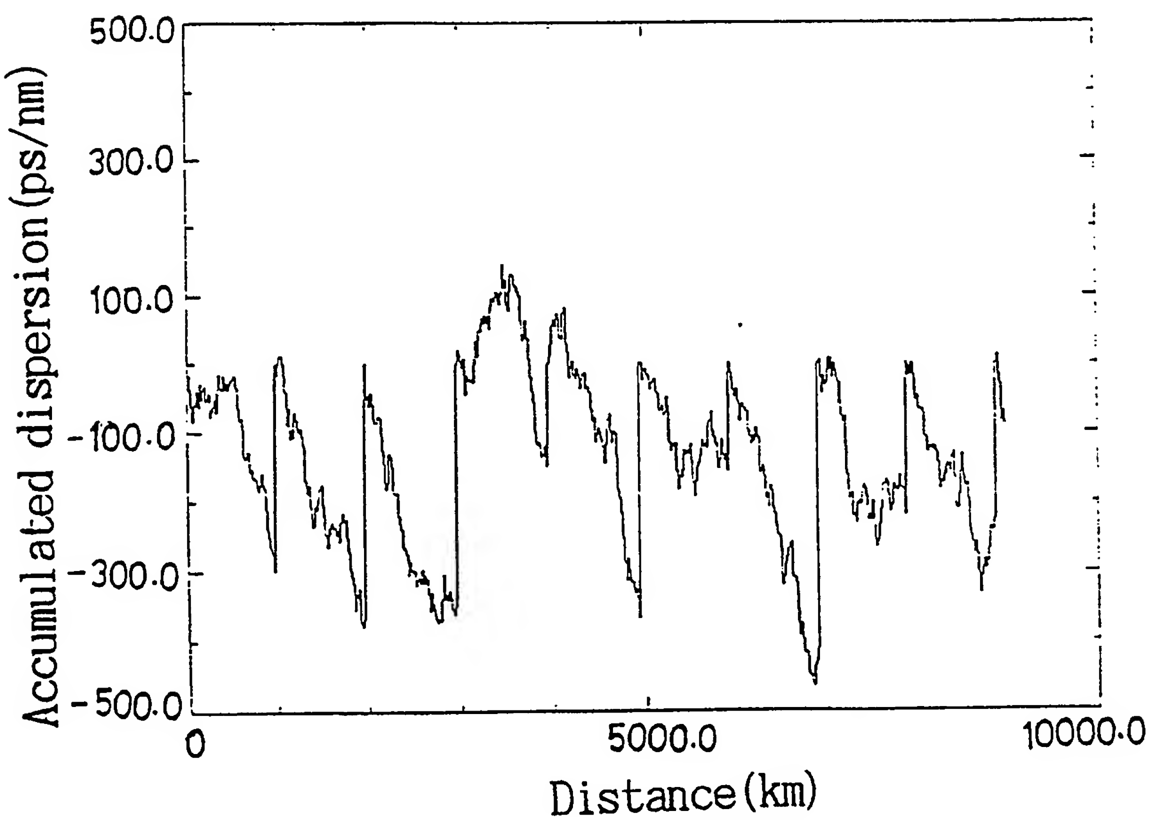

(A)
optical transmitter
3
2
optical amplifier
1
dispersive media
5
optical amplifier repeater transmission equipment
β
4
optical receiver
(B)
chromatic dispersion value
+
0
−
L1 (km)
average dispersion=-D1
(C)
accumulated chromatic dispersion value
+
0
−

Fig. 2



1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
-.1
-.2
Amplitude
.0
.5
1.0
1.5
2.0
2.5
3.0
Time(×200ps)

Fig. 3



500.0
300.0
100.0
-100.0
-300.0
-500.0
Accumulated dispersion(ps/nm)
0
5000.0
10000.0
Distance(km)

Fig. 4

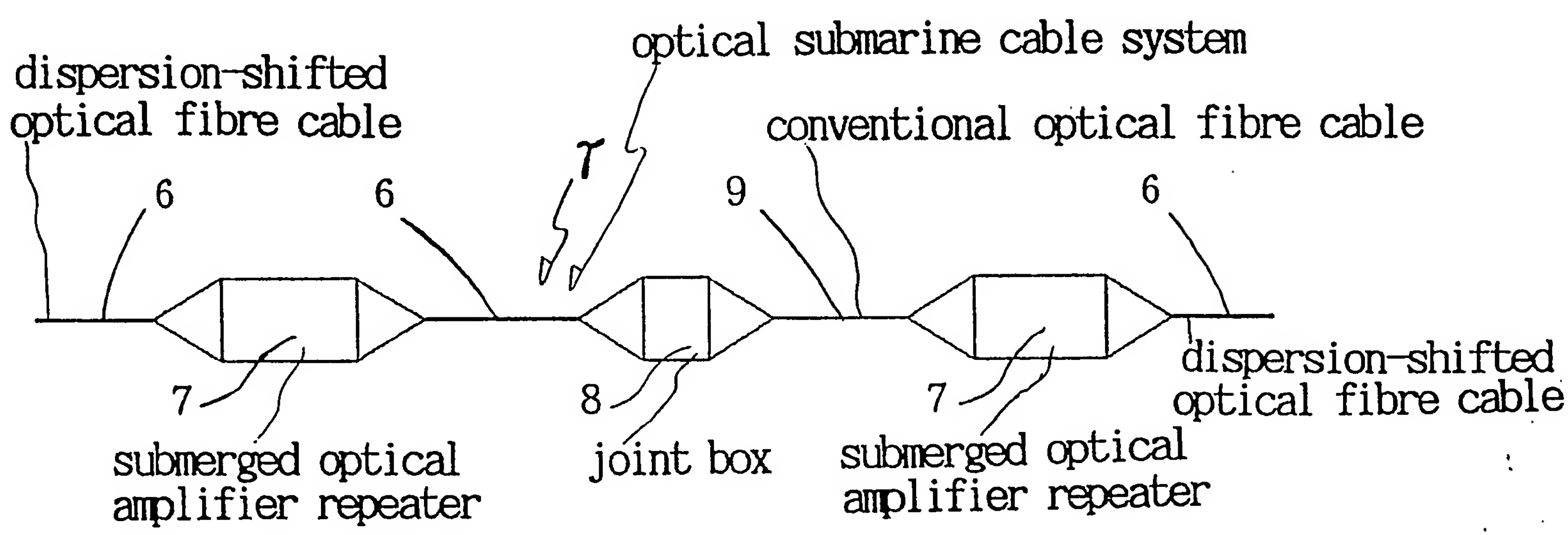
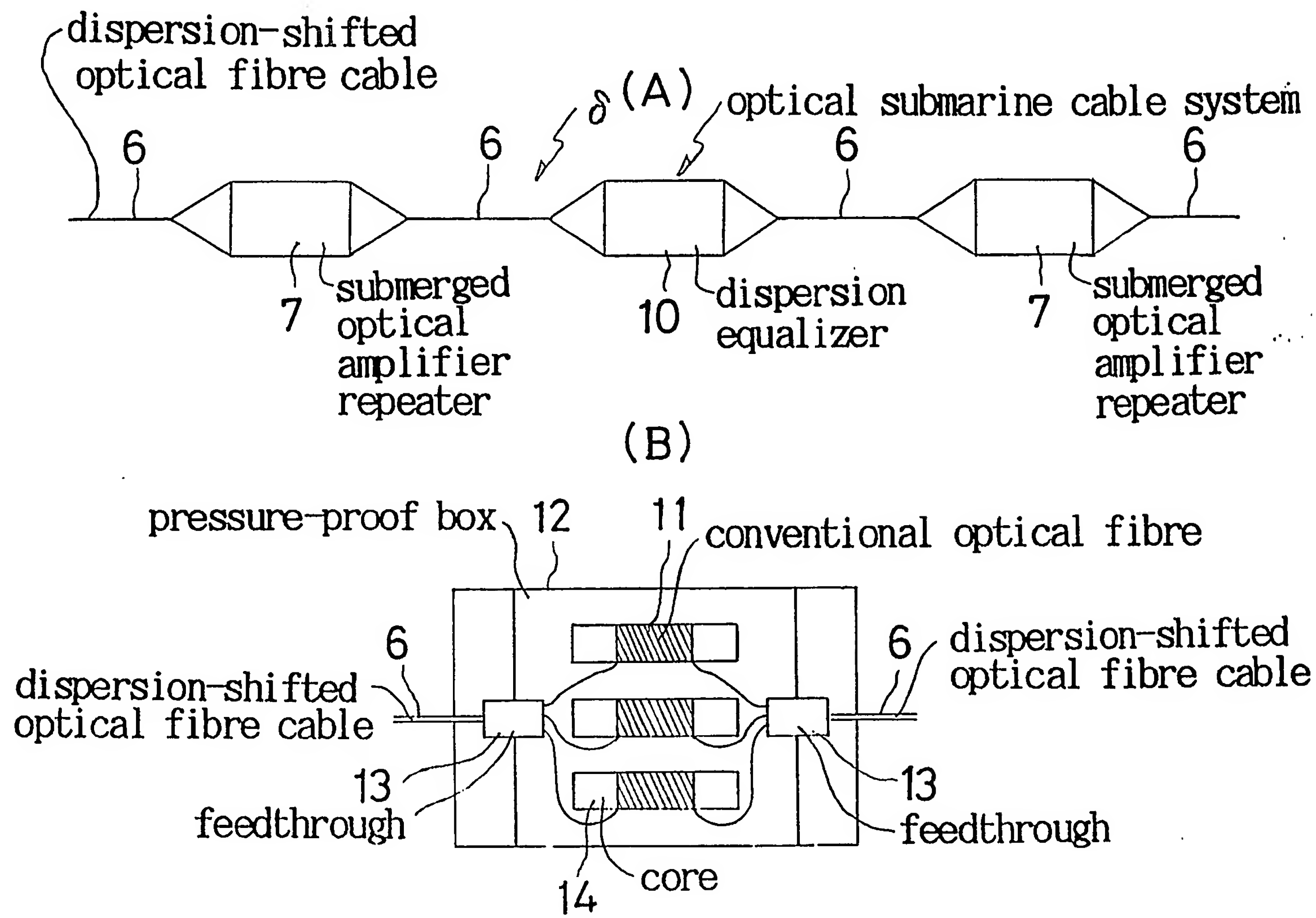
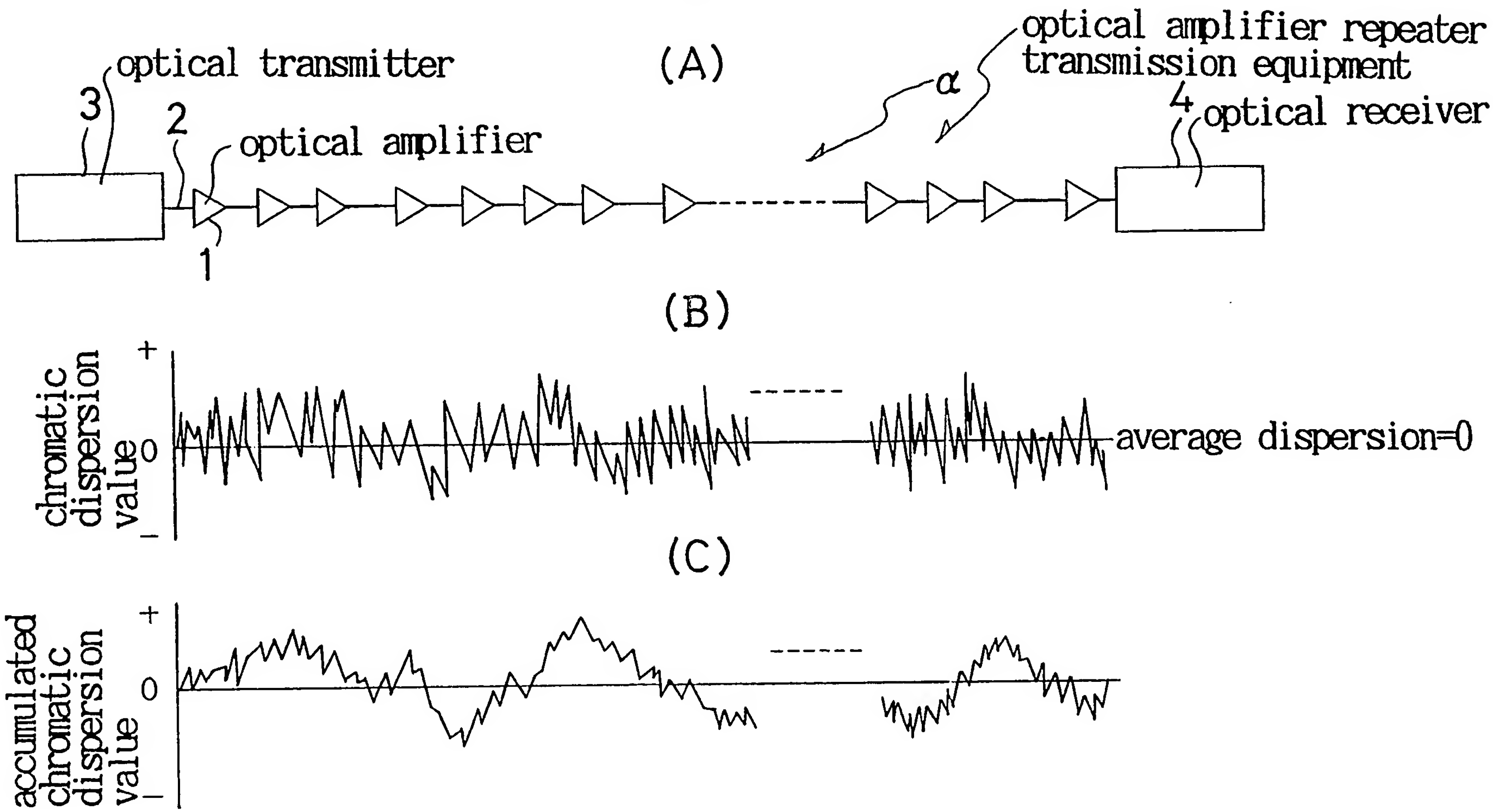

optical submarine cable system
dispersion-shifted optical fibre cable
conventional optical fibre cable
6
6
9
6
7
8
7
dispersion-shifted optical fibre cable
submerged optical amplifier repeater
joint box
submerged optical amplifier repeater

Fig. 5



(A)
dispersion-shifted optical fibre cable
optical submarine cable system
6
6
6
6
8
7
submerged optical amplifier repeater
10
dispersion equalizer
7
submerged optical amplifier repeater
(B)
pressure-proof box
12
11
conventional optical fibre
6
dispersion-shifted optical fibre cable
6
dispersion-shifted optical fibre cable
13
feedthrough
13
feedthrough
14
core

Fig. 6



(A)
optical transmitter
3
2
optical amplifier
1
α
optical amplifier repeater transmission equipment
4
optical receiver
(B)
chromatic dispersion value
+
0
–
average dispersion=0
(C)
accumulated chromatic dispersion value
+
0
–

Fig. 7

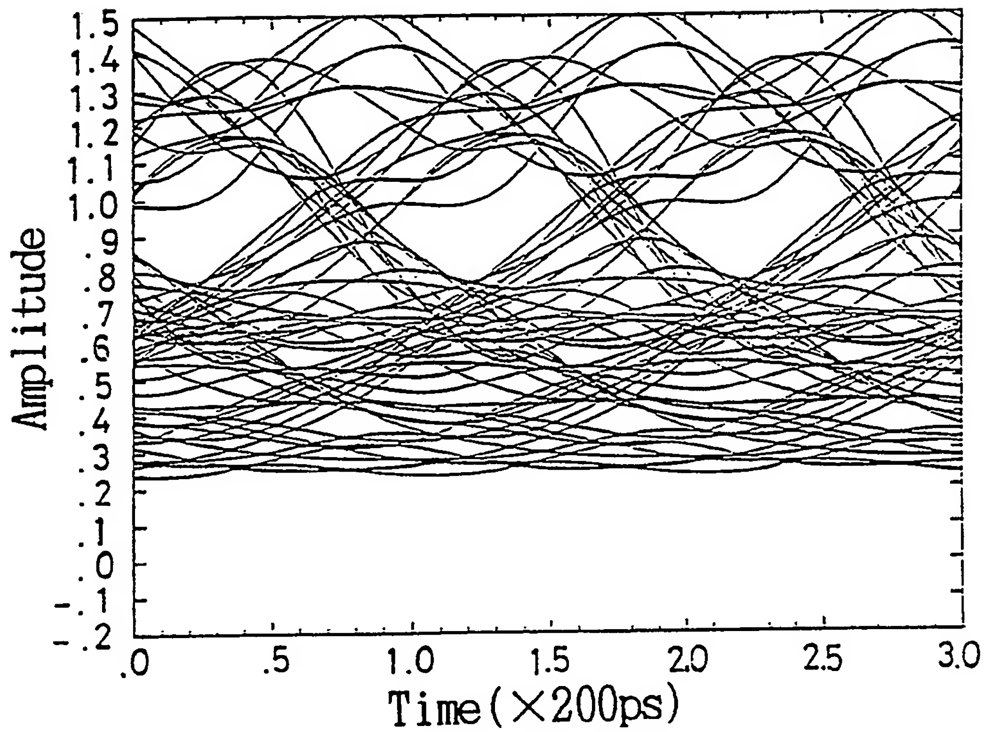

1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
-.1
-.2
Amplitude
.0
.5
1.0
1.5
2.0
2.5
3.0
Time(×200ps)

Fig. 8

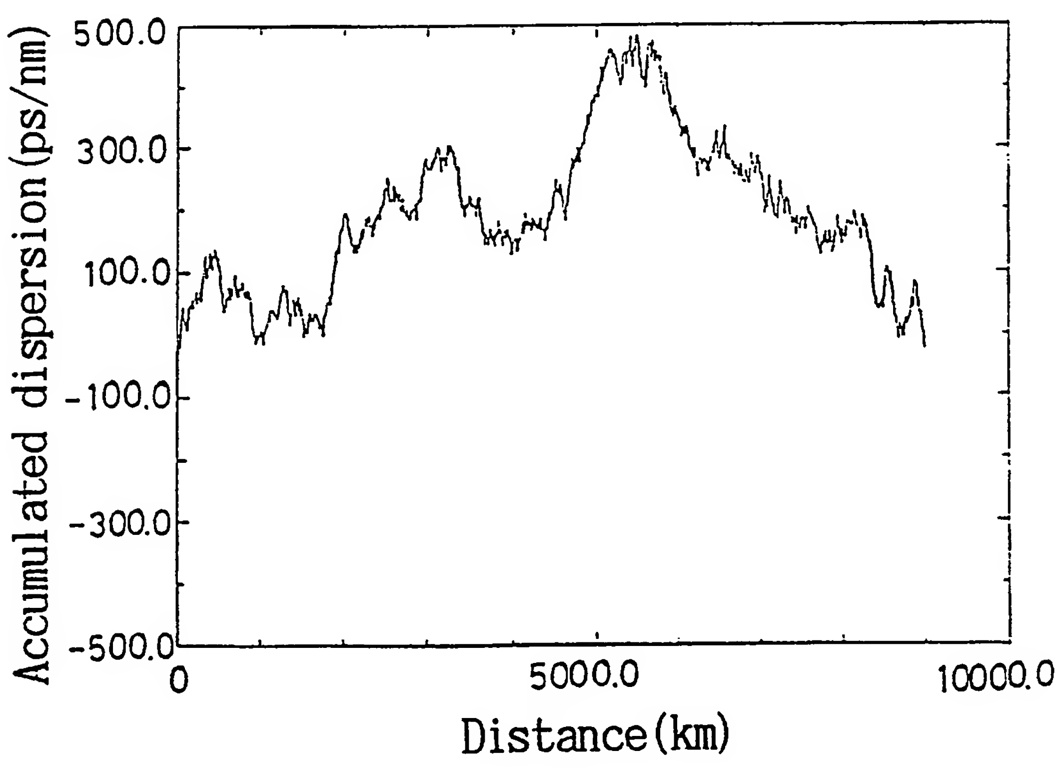
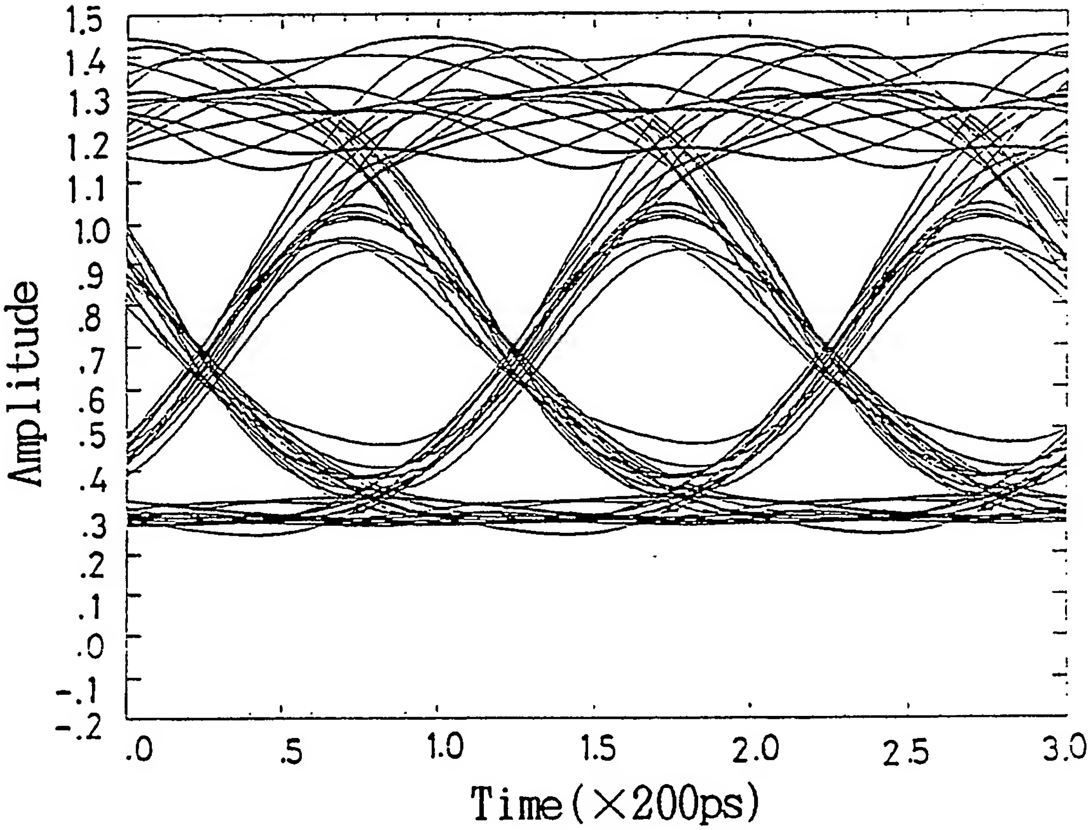
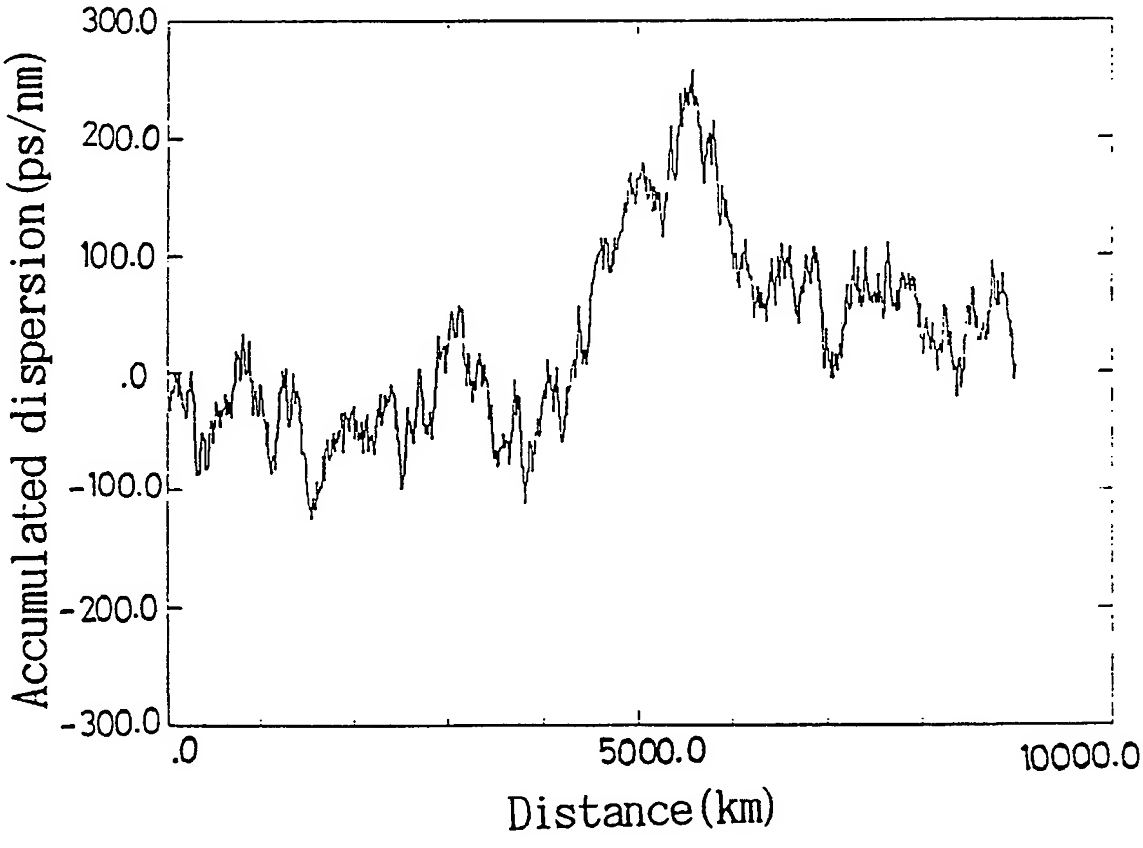

500.0
300.0
100.0
-100.0
-300.0
-500.0
Accumulated dispersion(ps/nm)
0
5000.0
10000.0
Distance(km)

Fig. 9



Amplitude
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
-.1
-.2
.0
.5
1.0
1.5
2.0
2.5
3.0
Time(×200ps)

Fig. 10



Accumulated dispersion(ps/nm)
300.0
200.0
100.0
.0
-100.0
-200.0
-300.0
.0
5000.0
10000.0
Distance(km)

2268018

SPECIFICATION

Title of the invention

Optical amplifier repeater transmission method and equipment

Background of the invention

The invention relates to the optical amplifier repeater transmission method and equipment that can propagate high-speed optical digital signals over a long distance in an optical amplifier repeater transmission system.

Being studied now is an optical amplifier repeater transmission system, which uses optical fibre, that propagates signal light over a long distance by compensating for optical fibre loss by inserting optical amplifiers into the optical fibre transmission at constant spacing.

In particular, work is underway to develop a practical optical submarine repeater transmission system that enables a long-distance propagation of signal light in 1.5 μm wavelength range by inserting into the transmission single-mode optical fibre at about equal spacing the optical amplifiers including optical fibre amplifiers using Er-doped fibre amplifiers to compensate for the propagation loss of optical fibre.

The inventors of the invention have actually conducted an experiment in which 5-Gbit/s digital signals were propagated over a distance equivalent to more than 10,000 km by circulating

the signals around a loop composed of optical fibre amplifiers and dispersion-shifted optical fibres whose zero-dispersion wavelength was shifted to 1.5 μm wavelength range. The experiment proved that very little signal light deterioration is incurred and that the transmission quality required of a commercial optical amplifier repeater transmission system can be obtained (Optical Fiber Communication Conference, OFC '92 "Characterization of chromatic dispersion effect on 5-Gbit/s ultralong-distance EDFA transmission using a circulating loop", H. Taga et al, Feb. 1992).

The inventors of the invention also demonstrated a 4,500-km transmission of 10-Gbit/s optical digital signals by inserting 136 equally-spaced optical fibre amplifiers amidst a dispersion-shifted optical fibre (Optical Fiber Communication Conference, OFC '92 "10Gbit/s, 4500km transmission experiment using cascaded Er-doped amplifiers", H. Taga et al, Feb. 1992).

Therefore, the long-distance optical amplifier repeater transmission system using optical amplifiers has been confirmed as feasible by experiments, and work is underway to realize its practical application.

In general, when high-speed optical digital signals are transmitted, the chromatic dispersion of transmission optical fibre accumulates in the optical amplifier repeater transmission system. As the accumulated chromatic dispersion grows, a waveform degradation occurs due to the chromatic dispersion effect. Because of this effect, it is necessary to select the transmission optical fibre used for the optical amplifier repeater transmission system so that the average zero dispersion wave-

length of the transmission optical fibre matches the signal wavelength.

Described below is the conventional method of selecting an optical fibre so that the average zero dispersion wavelength of the transmission optical fibre matches the signal wavelength.

Fig. 6(A) shows a schematic diagram of the conventional optical amplifier repeater transmission equipment, (B) the chromatic dispersion of the transmission optical fibre, and (C) a figure of accumulated dispersion in relation to transmission length.

In the figures, α denotes the optical amplifier repeater transmission device, 1 the optical amplifier, 2 the transmission optical fibre, 3 the optical transmitter, and 4 the optical receiver.

The conventional optical amplifier repeater transmission equipment α shown in Fig. 6(A) comprises alternately-connected optical amplifier 1 and transmission optical fibre 2 between optical transmitter 3 and optical receiver 4. In this case, the transmission optical fibre 2 is selected so its zero dispersion wavelength is alternated between positive and negative and so the average zero dispersion wavelength matches the signal wavelength, while avoiding the signal wavelength from matching the zero dispersion wavelength of transmission optical fibre 2. As shown in Fig. 6(C), when positive and negative optical fibres are connected, the accumulated chromatic dispersion changes from positive to negative alternatively.

On the other hand, in a long-distance optical amplification repeater transmission system, it is desirable to increase the

power of the signal light being propagated to avoid the effect of amplifier spontaneous emission noise generated by the optical amplifiers.

When the signal light power is increased above a particular limit, however, signal light deterioration occurs due to the fibre nonlinearity caused by the Kerr effect of transmission optical fibre 2. Especially when the signal wavelength matches the average zero dispersion wavelength of transmission optical fibre 2, the energetic coupling is enhanced due to the interaction between amplifier spontaneous emission noise from the optical amplifiers and the Kerr effect of signal light, and the exchange of energy is increased.

This effect is called four wave mixing. When this effect grows, the energy component of the transmitted signal light wave is converted to a spontaneous emission noise component, which drastically degrades the signal light waveform (IEEE Journal of Lightwave Technology, vol. 9, no. 3, pp. 356-361, 1991, "Single-channel operation in very long nonlinear fibers with optical amplifiers at zero dispersion", D. Marcuse).

Because of this effect, for conventional optical amplification repeater transmission equipment, transmission optical fibres 2 were selected and combined so the chromatic dispersion of transmission optical fibre 2 would alternate between positive and negative, the signal wavelength would not match the zero dispersion wavelength of the transmission optical fibre, and the average zero dispersion wavelength would match the signal wavelength.

When actually constructing an optical amplifier repeater

transmission equipment using the aforementioned method shown in Fig. 6, depending on the combination of transmission optical fibres, the section in which the chromatic dispersion is positive may continue over a long distance. This section would be sensitive to the strong effects of fibre nonlinearity, and the deterioration of signal light would be unavoidable.

Since this deterioration is due to nonlinearity, even if negative dispersion is continued later in an attempt to eliminate the accumulated positive dispersion, the signal light waveform cannot be restored to the original state. To provide an example, Figs. 7 and 9 show the computer simulations of transmission of 5 Gbit/s optical digital signal over 9,000 km for two cases: when positive dispersion is continuous and when it is not.

Figs. 8 and 10 show graphs of accumulated chromatic dispersion for each case. In both cases, the standard deviation of transmission optical fibre chromatic dispersion is 1.2 ps/km-nm. In case of Fig. 7, where positive dispersion is continuous, although chromatic dispersion is nearly zero at 9,000 km, positive dispersion continues to the 5,000 km point. Consequently, a severe deterioration in received signal light can be observed due to fibre nonlinearity and modulational instability, which is caused by positive dispersion.

On the other hand, in the latter case where the power of signal light is raised before it is transmitted, even in the region where the chromatic dispersion of transmission optical fibre is positive -- in essence, in abnormal dispersion area -- the nonlinearity caused by the Kerr effect of optical fibre

creates a modulational instability in the signal light, which in turn causes a deterioration in the signal light (Optics Letters vol. 9, no. 10, pp. 468-470, 1984 "Modulational instability of coherent optical-fiber transmission signals", D. Anderson and M. Liask).

Because of these problems, even if an optical fibre transmission is constructed by combining transmission optical fibres that alternate between positive and negative so the average zero dispersion wavelength matches the signal wavelength, transmitted signal light may deteriorate substantially, for example when the optical fibre combination is such that positive dispersion area is continuous.

It is desirable to constantly obtain the best optimized transmission characteristics to apply the optical amplification repeater transmission technique to long-distance transmission systems using high-speed optical digital signals including transoceanic optical submarine cable systems over 10,000 km in length.

In this respect, the invention provides the aforementioned optical amplifier repeater transmission using optical amplifiers with an optical amplifier repeater transmission method for transmitting stable high-speed optical digital signals over a long distance and transmission system.

Summary of the Invention

The invention solves said problems by employing the new,

unique embodiment and means described below.

In essence, the invention is an optical amplifier repeater transmission method, said method employed for an optical amplifier repeater transmission system for transmitting signal light, where a number of optical amplifiers are inserted into a transmission optical fibre at approximately constant spacing intervals, said technique, in order to enable the transmission of high-speed digital signals over a long distance, comprising exclusive properties of such that: the average zero dispersion wavelength of the transmission optical fibre used in the system is selected to be longer than the signal wavelength of along the system; and the accumulated chromatic dispersion of the transmission optical fibre in the required interval of the system length is forced to zero at the signal wavelength, whereas the chromatic dispersion is locally varied in that interval.

The invented equipment, an optical amplifier repeater transmission equipment for transmitting signal light, said equipment, in order to enable the transmission of high-speed digital signals over a long distance, comprising first exclusive features of such that: a transmission optical fibre for transmitting the signal light in which an average zero dispersion wavelength of said transmission optical fibre is longer than a wavelength of the signal light; a number of optical amplifiers that are inserted into said transmission optical fibre at roughly constant spacing for amplifying the signal that is transmitting in said transmission optical fibre; and a dispersive media that are inserted into said transmission optical fibre for providing a predetermined amount of a chromatic dispersion so that

the accumulated chromatic dispersion at the signal wavelength in the interval of said dispersive medea is substantially zero.

The invented equipment, an optical amplifier repeater transmission equipment for transmitting signal light, said equipment, in order to enable the transmission of high-speed digital signals over a long distance, comprising second exclusive features of such that: a transmission optical fibre for transmitting the signal light in which an average zero dispersion wavelength of said transmission optical fibre is longer than a wavelength of the signal light; a number of optical amplifiers that are inserted into said transmission optical fibre at roughly constant spacing for amplifying the signal light that is transmitting in said transmission optical fibre; and a dispersive media that are inserted into said optical amplifier for providing a predetermined amount of a chromatic dispersion so that the accumulated chromatic dispersion at the signal wavelength in the interval of said dispersive media is substantially zero.

The invented system, an optical amplifier repeater transmission equipment, has the third exclusive properties of said equipment of such that in the first or second exclusive properties of the invented equipment: said signal light has a signal wavelength of approximately 1.5 μ m, said transmission optical fibre comprises a dispersion-shifted fibre whose average chromatic dispersion is -D1 ps/km-nm, said dispersive media comprises a single-mode optical fibre whose chromatic dispersion becomes substantially zero at 1.3 μ m wavelength range of chromatic dispersion D2 ps/km-nm of L1 m, and said dispersive media

is inserted at every

$L2 = D2 \cdot L1/D1$.

The invented equipment, an optical amplifier repeater transmission equipment, has the fourth exclusive properties of said equipment of such that in the third exclusive properties of the invented equipment: said single-mode optical fibre is formed into transmission cable.

The invented equipment, an optical amplifier repeater transmission equipment, has the fifth exclusive properties of said equipment of such that in the third exclusive properties of the invented equipment: said single-mode optical fibre is coil-wound around a core material and sealed in a pressure-proof box of a dispersion equalizer.

The invention employs the technique and means such as those described above to vary chromatic dispersion locally and to force the accumulated chromatic dispersion in the section to zero. More specifically, in order to bring the dispersion of signal wavelength to zero, a transmission optical fibre whose average chromatic dispersion is zero is used and at certain intervals a dispersive media is used to provide a local positive dispersion. Thus, because the transmission optical fibre is set up so there are many negative dispersion sections at the signal wavelength, the effect of fibre nonlinearity is substantially reduced. In particular, when 1.5 μm wavelength is propagated across a dispersion-shifted optical fibre, a conventional optical fibre whose zero dispersion wavelength is in 1.3 μm wavelength range can be used, in which case the invention can easily be realized. Further, said conventional optical fibre can

easily be inserted amidst an optical amplifier repeater transmission system, where the conventional optical fibre is incorporated compactly in a pressure-proof box to serve as a dispersion equalizer.

Brief Description of the Drawings

Figure 1 is that (A) shows a schematic diagram of an optical amplifier repeater transmission equipment to which the first embodiment example of this invention is applied, (B) is a figure of its chromatic dispersion, and (C) a figure of accumulated chromatic dispersion;

Figure 2 is a computer simulation figure graph of the transmitted signal waveform of Fig. 1;

Figure 3 is a figure indicating the accumulated dispersion in relation to dispersion transmission distance of Fig. 1;

Figure 4 is a schematic diagram of the primary part of the optical submarine cable system to which the second embodiment example of the invention is applied;

Figure 5 is that (A) shows a schematic diagram of the primary part of optical submarine cable system to which the third embodiment example of the invention is applied, (B) shows a perspective projection schematic diagram of dispersion equalizer in (A);

Figure 6 is that (A) shows a schematic diagram of a conventional optical amplification repeater transmission equipment, (B) shows a graph of chromatic dispersion, (C) shows a graph of

accumulated chromatic dispersion;

Figure 7 is a computer simulation graph of transmitted signal waveform employing a conventional method when positive dispersion is continuous;

Figure 8 is a graph of accumulated dispersion in relation to dispersion transmission distance of Fig. 7;

Figure 9 is a computer simulation graph of transmitted signal waveform employing a conventional method when positive dispersion is not continuous; and

Figure 10 is a graph of accumulated dispersion in relation to dispersion transmission distance of Fig. 9.

Detailed description of embodiment of the invention

(First Embodiment)

Drawings are used to describe the first embodiment of the invention.

Fig. 1(A) shows a schematic diagram of an optical amplification repeater transmission equipment employing the embodiment, (B) its chromatic dispersion map, (C) accumulative chromatic dispersion map, Fig. 2 a computer simulation figure of the transmitted signal waveform when the embodiment is applied, and Fig. 3 a map indicating the accumulated dispersion in relation to dispersion transmission distance.

In the figures, 5 denotes the optical amplifier repeater transmission equipment of this embodiment, 1 the optical amplifier, 2 the transmission optical fibre, 3 the optical transmit-

ter, 4 the optical receiver, and 5 the dispersive media.

As shown in Fig. 1(A), in the embodiment, the transmission between optical transmitter 3 and optical receiver 4 comprises transmission optical fibre 2 and optical amplifiers 1 that are installed at about constant spacing intervals. In addition, dispersive media 5 are inserted into the transmission at appropriate intervals to provide local positive chromatic dispersion so the chromatic dispersion of the signal wavelength would be zero. As transmission optical fibre 2 is set up so it would mostly have a negative dispersion at signal wavelength, the effect of fibre nonlinearity of transmission optical fibre 2 is greatly reduced.

Consequently, by providing a positive chromatic dispersion for eliminating accumulated chromatic dispersion at required intervals, the signal light waveform can be restored to near original state. When a single-mode optical fibre whose chromatic dispersion becomes zero in 1.3 μm wavelength range is used as dispersive media 5 for providing a positive chromatic dispersion, the signal wavelength in 1.5 μm wavelength range expected for optical amplifier repeater transmission equipment β would have a large positive dispersion. Therefore, the transmission optical fibre may be extremely short, and the effect of fibre nonlinearity occurring at inserted transmission optical fibre can be adequately reduced.

Thus, by providing a positive chromatic dispersion for eliminating accumulated chromatic dispersion at required intervals, the signal light waveform can be restored to near original state, and in signal light transmission in 1.5 μm wavelength

range widely used for long-distance optical amplification repeater transmission systems, a single-mode optical fibre whose chromatic dispersion becomes zero in 1.3 μm wavelength range may be used as dispersive media 5 for providing a positive chromatic dispersion.

In essence, as an ordinary single-mode optical fibre whose chromatic dispersion becomes zero in 1.3 μm wavelength range incurs a large positive dispersion of 17-20 ps/km-nm at a signal light wavelength in the 1.5 μm wavelength range, the inserted transmission optical fibre 2 may be extremely short. Consequently, the effect of fibre nonlinearity due to the inserted transmission optical fibre can be sufficiently reduced.

In essence, given -0.3 ps/km-nm as the average chromatic dispersion of dispersion-shifted optical fibre and that the chromatic dispersion is adjusted approximately every 1,000 km, only 15 km of conventional single-mode optical fibre needs to be inserted.

Fig. 2 shows the computer simulation results when a transmission dispersion-shifted optical fibre whose average chromatic dispersion is -0.28 ps/km-nm and standard deviation is 1.2 ps/km-nm is used, 16.5 km conventional single-mode optical fibre is inserted every 973.5 km, and the same input signal as used in Fig. 7 is propagated 9,000 km. Fig. 3 shows, as Fig. 8 does, the accumulated chromatic dispersion in relation to dispersion transmission distance.

(Second Embodiment)

Drawings are used to describe the second embodiment of the

invention.

Fig. 4 shows a schematic diagram of the primary part of the optical submarine cable system to which the embodiment is applied.

In the figure, 1' denotes the optical submarine cable system, 6 the dispersion-shifted optical fibre cable, 7 submerged the optical amplifier repeater, 8 the joint box, and 9 the ordinary fibre cable.

In addition, parts and materials that are the same as those used in prior descriptions are denoted by the same symbols.

As shown in Fig. 4, this embodiment is applied to an optical submarine cable system employing a signal wavelength of around 1.5 μ m, and dispersion-shifted optical fibre cable 6 is used as the transmission optical fibre. In this example, the average chromatic dispersion of the dispersion-shifted optical fibre cable in Fig. 1 is assumed to be -D1ps/km-nm. Conventional optical fibre cable 9 comprises an conventional single-mode optical fibre with zero dispersion in 1.3 μ m wavelength range as the dispersive media. This conventional optical fibre cable 9 is inserted and connected every Lkm using joint box 8. If the interval at which conventional optical fibre cable 9 is inserted is set in advance, joint box 8 and submerged optical amplifier repeater 7 are connected, and the average chromatic dispersion of dispersion-shifted optical fibre cable 6 in the interval is set in advance, it is possible to determine the length of the inserted conventional optical fibre cable 9.

Here, according to the computer simulation, it is known that if conventional optical fibre cable 9 is inserted frequent-

ly over a long distance, the transmission characteristics will deteriorate rather than improve. Computer simulations such as those depicted by Figs. 2 and 3 also show that favorable transmission characteristics can be obtained by setting the length of conventional optical fibre cable 9 to about 5 km to 30 km and inserting the conventional optical fibre cable 9 every 500 km or more when propagating signal light over a distance as long as 9,000 km. Consequently, this also increases the possible propagation distance of the transmission system.

(Third Embodiment)

Drawings are used to describe the third embodiment of the invention.

Fig. 5(A) shows a schematic diagram of the primary part of optical submarine cable system 8 to which this embodiment is applied and (B) a perspective projection schematic diagram of dispersion equalizer 10 in (A).

In the figures, 8 denotes the optical submarine cable system, 6 the dispersion-shifted optical fibre cable, 7 the optical submerged amplifier repeater, 10 the dispersion equalizer, 11 the conventional optical fibre, 12 the pressure-proof box, and 13 the feedthrough.

In addition, parts and materials that are the same as hose used in prior descriptions are denoted by the same symbols.

Dispersion equalizer 10 contains conventional optical fibres 11. Each conventional optical fibre 11 is coil-wound around core 14. Cores 14 are sealed in parallel. Both ends of optical fibres 11 are converged to feedthroughs 13, 13 through

mounted at both ends of pressure-proof box 12. The ends of feedthroughs 13, 13 are series coupled to the external optical fibre cables 6, 6.

This embodiment shows a case where, instead of the conventional optical fibre cable 9 comprising the single-mode optical fibre shown in aforementioned embodiment 2 and in Fig. 4, ordinary single-mode optical fibres are contained in pressure-proof box 12 through feedthrough 13 at dispersion equalizer 10 whose chromatic dispersion becomes zero at 1.3 μm wavelength range. As dispersion-shifted optical fibre cable 6 usually comprises a number of optical fibres, in this embodiment, conventional optical fibre 11 can be adjusted to the appropriate length according to the accumulated dispersion of each optical fibre in dispersion-shifted optical fibre cable 6.

According to this invention, it is possible to transmit signal light in a dispersion area little affected by fibre nonlinearity by locally inserting dispersive media at certain intervals. Consequently, the invention allows a favorable transmission of high-speed optical digital signals over a long distance using optical amplifiers.

Furthermore, by varying the dispersion of the inserted dispersive media, it is possible to vary the average zero dispersion wavelength.

Therefore, it is possible to change the signal wavelength even after transmission optical fibre is procured. Particularly when an ordinary single-mode optical fibre whose chromatic dispersion becomes zero in 1.3 μm wavelength range is used as

the dispersive media, the aforementioned dispersion adjustment can easily be realized by changing the length of the fibre. In addition, as the dispersion equalizer comprises conventional optical fibres compactly sealed in a pressure-proof box, it can easily be inserted into an optical amplifier repeater transmission system.

Moreover, it is anticipated that this invention will be widely applied to high-speed optical digital communications using long-distance optical amplifier repeater transmission system, including optical cable system using optical amplifiers.

Claims

1. An optical amplifier repeater transmission method, said method employed for an optical amplifier repeater transmission system for transmitting signal light, where a number of optical amplifiers are inserted into a transmission optical fibre at approximately constant spacing intervals, said method, in order to transmit the transmission of high-speed digital signals over a long distance, comprising exclusive properties of such that:

the average zero dispersion wavelength of the transmission optical fibre used in this method is made longer than the signal wavelength used in the system; and

the accumulated chromatic dispersion of the transmission optical fibre in the required interval of the system length is forced to zero at the signal wavelength, whereas the chromatic dispersion is locally varied in that interval.

2. An optical amplifier repeater transmission equipment for transmitting signal light, said equipment, in order to transmit high-speed digital signals over a long distance, comprising:

a transmission optical fibre for transmitting the signal light in which an average zero dispersion wavelength of said transmission optical fibre is longer than a wavelength of the signal light;

a number of optical amplifiers that are inserted into said transmission optical fibre at roughly constant spacing for amplifying the signal light that is transmitting in said transmission optical fibre; and

a dispersive media that are inserted into said transmission optical fibre for providing a predetermined amount of a chromatic dispersion so that the accumulated chromatic dispersion at the signal wavelength in the interval of said dispersive media is substantially zero.

3. An optical amplifier repeater transmission equipment for transmitting signal light, said equipment, in order to transmit high-speed digital signals over a long distance, comprising:

a transmission optical fibre for transmitting the signal light in which an average zero dispersion wavelength of said transmission optical fibre is longer than a wavelength of the signal light;

a number of optical amplifiers that are inserted into said transmission optical fibre at roughly constant spacing for amplifying the signal light that is transmitting in said transmission optical fibre; and

a dispersive media that are inserted into said optical amplifier for providing a predetermined amount of a chromatic dispersion so that the accumulated chromatic dispersion at the signal wavelength in the interval of said dispersive media is substantially zero.

4. An optical amplifier repeater transmission equipment according to the claim 2 or 3, wherein

said signal light has a signal wavelength of approximately 1.5 μm,

said transmission optical fibre comprises a dispersion-

shifted fibre whose average chromatic dispersion is -D1 ps/km-nm,

said dispersive media comprises a single-mode optical fibre whose chromatic dispersion becomes substantially zero at 1.3 μm wavelength range of chromatic dispersion D2 ps/km-nm of L1 m, and

said dispersive media is inserted at every

$L2 = D2 \cdot L1/D1$.

5. An optical amplifier repeater transmission equipment according to the claim 4, wherein said single-mode optical fibre is formed into a transmission cable.

6. An optical amplifier repeater transmission equipment according to the claim 4, wherein said single-mode optical fibre is coil-wound around a core material and sealed in a pressure-proof box of a dispersion equalizer.

7. An optical amplifier repeater transmission method substantially as hereinbefore described with reference to Figures 1 to 5 of the accompanying drawings.

8. An optical amplifier repeater transmission equipment substantially as hereinbefore described with reference to Figures 1 to 5 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9311826.3

Relevant Technical fields

(i) UK Cl (Edition L) H4B (BK18)

(ii) Int Cl (Edition 5) H04B

Search Examiner
DR E PLUMMER

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
14 JULY 1993

Documents considered relevant following a search in respect of claims 1-3 AT LEAST

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2260048 A (ATT) eg abstract, page 6 lines 12-15, page 8 line 20	1-3
X P	EP 0539177 A2 (NEC) whole document	1-3
X	US 4238648 (ISEC) whole document; NB column 1 lines 6 to 23	1-3

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).